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(54) Fiber separator for producing fiber reinforced metallic or resin body.

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PATENT ABSTRACTS OF JAPAN, Vol 9, No 146, (M-389)(1869), 21 June 1995 & JP-A-6023255 (SUMITOMO KEIKINZOU) 05.02.85

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De cripti n

The present inv ntion relates to a fiber separator for separating a bundle of fibers into individual fibers in such a manner that the fiber bundle is flattened for a subsequent fiber treatment, said fiber separator comprising a composite separating roller device located between guide and tensioning rollers, the fiber bundle running under tension between the guide and tensioning rollers, said composite roller device being composed of a plurality of roller elements of the same size with a barrel-shaped profile in an axial sectional view, and means for rotating said composite roller device so that each roller element being in contact with said fiber bundle is moving in the direction of a movement of the fiber bundle. Said fiber separator is preferably being used in producing a fiber reinforced metallic or resin body.

A fiber separator of this general type is known from Patent Abstracts of Japan, vol. 9, no. 146 (M-389) (1869), June 21, 1985 and JP-A-6023255 (SUMITOMO KEIKINZOKU) of February 2, 1985. In this known fiber separator the composite separating roller device comprises a plurality of rotatable roller elements having a barrel-shaped profile and being sequentially arranged along the path of the running fiber bundle. Further, the flattened fiber bundle according to the teachings of the documents cited is subjected to streams of a gaseous fluid while being slackened and retained by a belt wrapper, whereby filaments can be wound on a rotatable drum. In the known device pins provided at the circumference of a circular rotatable disc are cooperating with the belt wrapper for transportation and withdrawal of the flattened fiber bundle.

Further, in recent years, there has been developed a fiber reinforced metallic body using a reinforcing fiber such as alumina fiber, silica fiber, silicon carbide fiber, boron fiber, nitrosilicate fiber, carbon fiber or the like with a matrix metal such as aluminium, magnesium, titanium, copper or the like. Such a fiber reinforced metallic body has been used for various kinds of mechanical parts or structural members in many fields of industry.

JP-B- (Japanese Examined Patent Publication) 62-27142 discloses an apparatus for producing such a fiber reinforced metallic body, which apparatus is of the following arrangement.

A drum with a bundle of such fibers as above wound thereon is mounted for rotation at an inlet of the apparatus for supplying the fiber bundle into the apparatus. A pair of upper and lower fiber separating drums defining a nib therebetween are provided downstream of the fiber supply drum. Th paired drums are forced to rotate for feeding th fiber bundle from th supplying drum through th nib. A fiber separator is provided betw en the supply drum and the paired fiber separating drums for blowing air ont the fiber bundle laterally or in a direction perp ndicular to a fiber feed directi n to ther by rend r the fiber bundl to be separated into individual fibers which are to b forced to pass through the drum nib. A plasma spray device for plasma-spraying a matrix metal such as above is provided downstream of the paired drums. Downstream of the plasma-spraying device, there are provided a heating device, a pressing device and a winding drum in this order. The separated fibers are forced to move toward the winding drum. While moving, the fibers are subjected to the plasma-spray of a molten metal or melt with the result that a prepreg sheet having a lower dense metallic surface and an upper spongy metallic surface is formed with the separated fibers being embedded within a metal deposition. The prepreg thus formed is then softened using the heating device and is pressed using the pressing device to form a fiber reinforced metallic sheet, which is then wounded by the winding drum thereon.

With the above prior art apparatus, however, there is a problem residing in that irregularity in a degree of fiber separation is likely to occur due to the blowing of a pressurized air with the result that a uniform fiber separation with a desired fiber orientation cannot be attained.

In this regard, proposed has been a process for use in preparation of a fiber reinforced resin body, wherein such fiber separation is effected while the fibers are forced to move through nibs defined by a plurality of paired rollers. Such idea, however, does not always attain a satisfactory effect in the fiber separation.

The object of the present invention is to provide a new fiber separator overcoming the above mentioned problems.

This object according to the present invention is achieved by means of a fiber separator of the type indicated above, said fiber separator being characterized in that said composite roller device is a rotatable roller device wherein said roller elements are arranged along the circumference of a circle, a center of which forms a rotation axis of said composite roller device, said roller elements being stationary at said circle, while being rotatable about said rotation axis along said circle, that the composite roller device is positioned relative to the fiber bundle such that during one rotation thereof about said rotation axis each roller element separately comes into contact with the fiber bundle, such that a contacting angle of the fibers with the sole contacting roller element is not more than about 45°.

The inventive fiber separator is preferably used in producing a fiber r inforced metallic or resin body.

Preferably, each barr l-shaped roll r el ment has a profile rotation-symmetrical about its axis. The symmetrical profil , in a cross-sectional view taken along the axis, has opposite smooth surface lines of

an oppositely convex form. Th pposit surface lines ar symmetrical to a center line f the roller perpendicular to th axis. A width b tween th opposite surface lines in a perpendicular direction is incr ased in an axial direction toward the center line.

The invention will be further explained with reference to the enclosed drawings, in which:

Figure 1 is a plan view showing a fiber separator of the present invention, which separator is preferably incorporated in an apparatus as shown in Fig. 3;

Fig. 2 is a cross-sectional view taken along the line II-II in Fig. 1;

Fig. 3 shows a process of preparing reinforcing fibers to be used for a fiber reinforced metallic body, according to the present invention; and

Fig. 4 shows a process of preparing a fiber reinforced metallic body according to the present invention, which process is carried out subsequent to the process as shown in Fig. 3.

Referring to Figs. 1 to 3 an apparatus for carrying out a process of preparing reinforcing fibers according to the present invention as shown in Fig. 3 comprises a fiber separator as shown in Figs. 1 and 2.

In the apparatus, there is provided a drum 2 mounted rotatably on a base 1 at an end of the apparatus. The drum 2 has a bundle 3 of fibers 3A to be treated, which was wound thereon in a preceding process. The fibers 3A to be treated are monofilaments and, may be, for example, silicon carbide fibers nitrosilicate fibers, inorganic Si - Ti fibers produced by sintering polymetallic carbosilane ("Tirans fibers", trademark of the applicant) or Zr-C-O inorganic fibers. The fiber bundle 3 consists of about 200 to about 10,000 fibers 3A, each having a diameter of, for example, 10 μm. The number of fibers 3A in the bundle 3 depends on the kinds and diameters of fibers.

The fiber bundle 3 is drawn from the initial drum 2 to pass through the apparatus, by a final drum 22, which is provided at the opposite end of the apparatus to wind the fibers 3A thereon.

The fiber bundle 3 runs at a constant speed in the apparatus, and is guided by guiding rollers 4, and 5 to an electric furnace 6 for desizing.

There are provided a plurality of guiding rollers 7, 10, and 11 downstream of the furnace. Between the rollers 10 and 11, an ultrasonic infiltrating device 9 is provided having a vessel 8 containing an aluminum paste and a pair of dipping rollers 9a therein. Downstream of the roller 11, a drying device 14 having a hot air blower 12 and a drying furnace 13 is provided between the roller 11 and a roller 11'.

Numeral 15 in Fig. 3 denotes the fiber separator of the present invention as shown in Fig. 1, which is provid d downstream f th roller 11'.

The fiber separator 15 comprises a rotatabl roller d vice, namely a separating roller 20 including f ur roller elements 20b, a base 16 and a horizontally xtending frame 17 supp rting a rotatable roller 18, fixed rollers 21 and grooved guide rollers 19. In Fig. 1, the frame 17, however, is omitted. The roller elements 20b are fix d to a pair of opposite disk plates 20a to form the separating roller 20 in such an arrangement that their axes are located along a circle, and each roller element is spaced apart equally from the neighboring ones. A rotation shaft 20' extends through both the disk plates 20a at a center of the circle, but is fixed thereto and is supported by the frame 17 rotatably by means of bearings (not shown). A motor (not shown) is provided to rotate the separating composite roller 20 or rotate the disk plates 20a with the roller elements 20b. The roller elements 20b per se are, therefore, revolved along the circle by the motor, but are not free to rotate about their axes, while the separating composite roller 20 per se is rotated with the rotation shaft 20'.

The roller elements 20b are of the same size and of the same bulging thick-center profile symmetrical about the respective axis. The roller elements 20b are preferably made of teflon, alumina, titania or so.

According to the separating composite roller 20 composed of the four roller elements 20b, the fiber bundle 3 is forced to come in contact with the separating composite roller 20 intermittently while it is running and the separating composite roller 20 is rotating. In particular, the fibers are forced to alternately come in contact with each of the roller elements 20b sequentially.

By the separating composite roller 20, the fiber bundle 3 is forced to be separated into individual fibers at the bulging surface of each of the roller elements 20b in such a manner that the fiber bundle is flattened along the bulging surfaces with a separation width W as shown in Fig. 1.

The flattened fiber bundle having the separation width W forms a plurality of piled fiber layers.

When a circumferential speed of the revolving roller elements 20b is lower than a running speed of the fiber bundle 3, separated fibers are likely to gather together. In this regard, it is preferable to determine the circumferential speed of the roller elements 20b to be the same as or a little bit higher than the running speed of the fiber bundle 3.

The running speed of the fiber bundle may be at a level of 1 to 3 m/min, and thus the circumferential speed of the roller elements can be adjusted to a desired value relative to the fiber running speed.

The bulging thick-center roller elements 20b have a radius of curvature preferably of 30 mm to 100 mm in consideration of the fact that the smaller the curvature radius, the larger the width of the fiber separation is, but th fibers are likely to be apart from a center line of the roll r elem nt.

Preferably, th fiber bundle is forced to run along a center lin f th s parating composite roll r 20. If a contact angle θ of the fiber bundle 3 with one of the

roller elements 20b is larger with a fixed radius of curvature, a fiber separation width W becomes larger. A preferable contact angl θ is about 45° or less.

On of the fix d rollers 21 is connect d t the frame 17 and the other one is connected to a bracket 22 connected to the frame 17, so that the fixed rollers 21 are in upper and lower positions, respectively. The upper and lower fixed rollers 21 in combination cause the fiber bundle 3 to be kept flattened with the fiber separation width W being kept constant. Downstream of the fixed tensioning rollers 21, there is provided a hybrid treatment device 30, which comprises a vessel 31 containing a suspended solution of SiC powder, guiding rollers 32 and dipping rollers 33. By this device 30, the separated fibers 3A are subjected to a hybrid treatment with the effect that: the fibers are provided with an enhanced uniform separation characteristic; the fibers are improved so that the fibers are prevented from being damaged or deteriorated in a subsequent process for preparing a fiber reinforced metallic body (which will be explained herein later); and adhesion of the fibers to a matrix metal is improved in the subsequent process.

The final drum 23 is mounted rotatably on a base 24 located downstream of the lower fixed roller 21 to wind the separated fibers. The final drum is rotated by the motor. Numeral 21' designates a further tensioning roller.

With the above apparatus, a fiber bundle 3 wound on the initial drum 2 runs through the apparatus and the fibers are wound by the final drum 23 thereon via the various rollers 4, 5, 10, 7, 9a, 7', 11, 11', 18, 19, 20 (20a), 21, 32, 33, and 21' by rotating the final drum 23. The rotation of the final drum 23 is adjusted so that a running speed of the fiber bundle 3 is substantially constant over the entire winding operation from an initial stage to a final stage.

The fiber bundle 3 rewound from the initial drum 2 is first introduced into the electric furnace 6. The fibers 3A were subjected to a sizing treatment using a binding agent in a previous process to form the fiber bundle 3. In this connection, the binding agent adhered to the fibers is removed in the furnace 6. The fiber bundle 3 is then introduced into the ultrasonic infiltrating device 9, where aluminum paste contained in the vessel 8 is infiltrated into the fiber bundle 3 with the effect that a uniform separation characteristic of the fibers is improved. The resultant fiber bundle is then introduced into the dryer 14, where a hot air blown from the blower 12 renders the infiltrated paste to be dry in the fiber bundle. The dried fiber bundle is introduced into the fiber separator 15. With the fiber separator 15, the fiber bundle is separated into the individual fibers in a direction of th axis of th separating roller 20 du to the bulging thick-center profile of each roller element 20b, while th running fiber bundl is in intermitt nt c ntact with th s parating composite r ller 20 or alternate contact with the respective roller lements 20b.

The separated fibers in the bundle are then subj cted to tension by th upp r and l wer fixed roll rs 21, 21' with the effect that the separat d fibers are flattened and the separation width W is kept. The resultant fiber bundle is then subjected to the hybrid treatment in the device 30. Thereafter, the fiber bundle is wound by the final drum 23 thereon. The winding is carried out while the final drum 23 is reciprocating axially, so that the fibers are wound in a helical manner over the entire axial length of the drum 23.

In a case where a prepreg sheet to be prepared with the separated fibers for the fiber reinforced metallic body is designed to have a thickness of 100 to 150 μm, the separation width W of the fiber bundle 3 is determined so as to have the fiber bundle form 3 to 5 fiber layers in a piled manner, each having substantially the same separation width W.

The final drum 23 with the hybrid-treated fibers wound thereon is then subjected to the subsequent process of preparing a prepreg sheet forming the fiber reinforced metallic body as shown in Fig. 4.

Referring to Fig. 4, the drum 23 as a starting or initial drum is set to operate with an apparatus 40 so that the fibers on the drum 23 are forced to run through the apparatus 40 via guiding rollers 41, 42, and 43 and are wound by a final drum 60 thereon. The fibers 3A from the drum 23 are preheated by a heater 45, and are then subjected to a plasma-spray of a matrix molten metal by a plasma-spraying device 46 to thereby form in combination with the melt a prepreg sheet 50 with the fibers embedded therein on the heater 45. The prepreg sheet 50 is guided by the roller 42 and introduced onto a heater 47. The prepreg sheet is pressed by a pressing roller 48 against an upper surface of the heater 47, whereby the prepreg sheet becomes dense with its surfaces being smooth. The prepared prepreg sheet 50 is then wound by the final drum 60 thereon.

According to the present invention, the plasma-spray of the molten metal is applied to the preheated fibers. This is advantageous in that the sprayed melt is smoothly and uniformly infiltrated into space gaps among the separated fibers with the result that the melt is adhered to the fibers uniformly.

Further, since the prepreg sheet is hot-pressed by the pressing roller 48 and the heater 47 in combination, adhesion of the fibers to the metal is improved and a high dense prepreg sheet is obtained.

It should be appreciated that the above mentioned processes as shown in Figs. 3 and 4 can be applied effectively for preparing not only a fiber reinforced metallic body, but also a fiber reinforced resin body. Further, both the processes for preparing the fiber reinforced metallic or resin body as shown in Figs. 3 and 4 may b , of course, combined to form a continuous process with th drum 23 b ing mitted.

With respect to the fiber separator, the pr sent

invention is not limited to the embodiment as shown in Figs. 1 and 2. Anoth r mbodiment may be covered, wherein each corresponding roller el ment has a plurality of bulging thick center roller sections integrated to form a single rod. Each roller section has substantially the same profile as that of each roller element 20b as shown in Fig. 1. The other embodied fiber separator is used for separating a plurality of fiber bundles concurrently on respective roller sections.

The roller elements forming the composite roller according to the present invention are not free to rotate. If they are allowed to rotate when the fiber bundle runs in contact with the roller elements, a desired fiber separation cannot be ensured.

Claims

1. A fiber separator (15) for separating a bundle (3) of fibers into individual fibers (3A) in such a manner that the fiber bundle (3) is flattened for a subsequent fiber treatment, said fiber separator (15) comprising a composite separating roller device (20) located between guide and tensioning rollers (18, 19, 21), the fiber bundle (3) running under tension between the guide and tensioning rollers (18, 19, 21), said composite roller device (20) being composed of a plurality of roller elements (20b) of the same size with a barrel-shaped profile in an axial sectional view, and means for rotating said composite roller device (20) so that each roller element (20b) being in contact with said fiber bundle (3) is moving in the direction of a movement of the fiber bundle (3),
characterized in
that said composite roller device is a rotatable roller device (20) wherein said roller elements (20b) are arranged along the circumference of a circle, a center of which forms a rotation axis (20') of said composite roller device (20), said roller elements (20b) being stationary at said circle, while being rotatable about said rotation axis (20') along said circle;
that the composite roller device (20) is positioned relative to the fiber bundle (3) such that during one rotation thereof about said rotation axis each roller element (20b) separately comes into contact with the fiber bundle (3), such that a contacting angle (θ) of the fibers (3A) with the sole contacting roller element (20b) is not more than about 45°.

2. A fiber separator according to claim 1, wherein a surface line of ach said roller element (20b) in an axial secional vi w has a radius of curvatur ranging from 30 mm to 100 mm.

3. Using a fiber separator according to claims 1 or 2 in an apparatus for producing fiber reinforced metallic or resin bodies, wherein downstr am of the fiber s parator ther is provid d a treatment device (40), wherein the s parated fibers (30) are embedded within a metal or resin deposition.

Patentansprüche

1. Faserseparator (15) zum Aufteilen eines Bündels (3) von Fasern in einzelne Fasern (3a) in einer solchen Weise, daß das Faserbündel (3) für eine anschließende Faserbehandlung abgeflacht wird, wobei der Faserseparator (15) eine zusammengesetzte Separierwalzenanordnung (20) umfaßt, die zwischen Führungs- und Spannwalzen (18, 19, 21) angeordnet ist, und wobei das Faserbündel (3) unter Spannung zwischen den Führungs- und Spannwalzen (18, 19, 21) hindurchläuft, wobei die zusammengesetzte Separierwalzenanordnung (20) aus mehreren Walzenelementen (20b) derselben Größe und mit einem balligen Profil im axialen Querschnitt zusammengesetzt ist und wobei Einrichtungen zum Antreiben der zusammengesetzten Walzenanordnung (20) vorgesehen sind, derart, daß jedes Walzenelement (20b), welches in Kontakt mit dem Faserbündel (3) steht, in Richtung der Bewegung des Faserbündels (3) läuft,
dadurch gekennzeichnet, daß die zusammengesetzte Walzenanordnung eine drehbare Walzenanordnung (20) ist, bei der die Walzenelemente (20b) längs des Umfangs eines Kreises angeordnet sind, dessen Mittelpunkt die Drehachse (20') der zusammengesetzten Walzenanordnung (20) bildet, wobei die Walzenelemente (20b) auf dem Kreis stationär sind, während sie (gleichzeitig) längs des Kreises um die Drehachse (20') drehbar sind;
daß die zusammengesetzte Walzenanordnung (20) relativ zu dem Faserbündel (3) derart angeordnet ist, daß jedes Walzenelement (20b) bei einer Drehung um die Drehachse separat in Kontakt mit dem Faserbündel (3) gelangt, derart, daß der Kontaktwinkel (θ) der Fasern (3A) mit dem einzigen berührenden Walzenelement (20b) nicht größer als etwa 45° ist.

2. Faserseparator nach Anspruch 1, bei dem eine Oberflächenlinie jedes der Walzenelemente (20b) im axialen Querschnitt einen Krümmungsradius besitzt, der von 30 bis 100 mm reicht.

3. V rwendung ein s Fas rs parators nach Anspruch 1 d r 2 in ein r Vorrichtung zum Herstellen von faserverstärkten Metall- oder Kunststoffkörpern, wobei stromabwärts von dem Fas rseparator ine Behandlungseinrichtung (40) vorge-

s h n ist, in der di aufgeteilten (separierten) Fa s rn (30) in eine Metall- der Harzmasse eingebettet werden.

Revendications

1. Séparateur de fibres (15) pour séparer un faisceau (3) de fibres en fibres individuelles (3A) de telle façon que le faisceau de fibres (3) soit aplati en vue d'un traitement subséquent des fibres, ce séparateur de fibres (15) comprenant un dispositif à rouleau séparateur composite (20) situé entre des rouleaux de guidage et de tension (18,19,21), le faisceau de fibres (3) défilant sous tension entre les rouleaux de guidage et de tension (18,19,21), le dispositif à rouleau composite (20) étant composé d'une pluralité de rouleaux élémentaires (20b) de même dimension, ayant un profil en forme de tonneau dans une vue en coupe axiale, et des moyens pour faire tourner le dispositif à rouleau composite (20) de telle facon que chaque rouleau élémentaire (20b), lorsqu'il est en contact avec le faisceau de fibres (3), se déplace dans la direction du mouvement du faisceau de fibres (3), caractérisé en ce que le dispositif à rouleau composite est un dispositif à rouleau rotatif (20) dans lequel les rouleaux élémentaires (20b) sont disposés suivant la circonférence d'un cercle dont le centre forme un axe de rotation (20') du dispositif à rouleau composite (20), les rouleaux élémentaires (20b) étant fixes sur ce cercle tout en tournant autour de l'axe de rotation (20'), le long du cercle, en ce que le dispositif à rouleau composite (20) est disposé, par rapport au faisceau de fibres (3), de telle facon que pendant un tour de ce dispositif autour de son axe de rotation, chaque rouleau élémentaire (20b) vienne séparément en contact avec le faisceau de fibres (3) de telle façon que l'angle de contact θ des fibres (3A) avec le seul rouleau élémentaire en contact (20b) ne soit pas supérieur à environ 45°.

2. Séparateur de fibres suivant la revendication 1 caractérisé en ce qu'une génératrice de chaque rouleau élémentaire (20b) présente un rayon de courbure, dans une vue en coupe axiale, allant de 30 millimètres à 100 millimètres.

3. Utilisation d'un séparateur de fibres suivant la revendication 1 ou 2 dans un appareil destiné à la production de corps métalliques ou en résine renforcés par des fibres, dans lequel il est prévu, en aval du séparateur d fibres, un dispositif de traitement (40) dans l qu l les fibres séparées (30) sont noyé s dans un dépôt métalliqu u de résine.

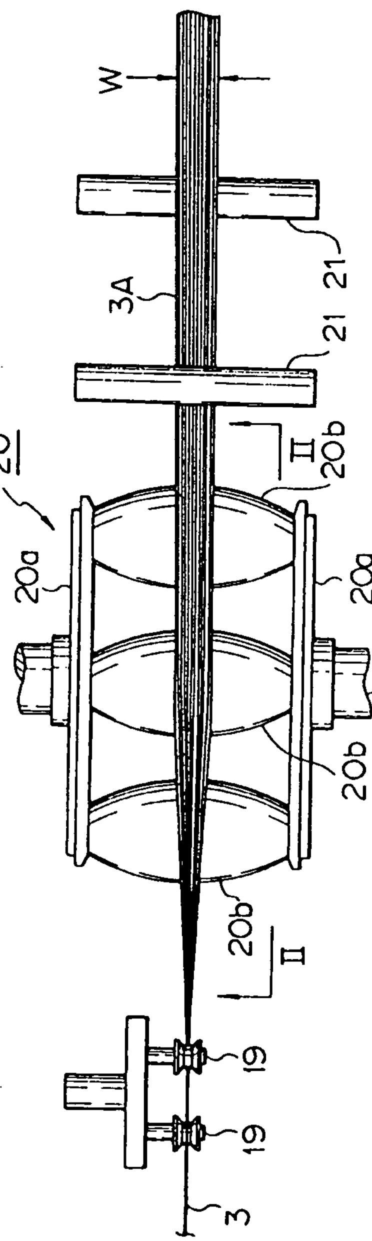
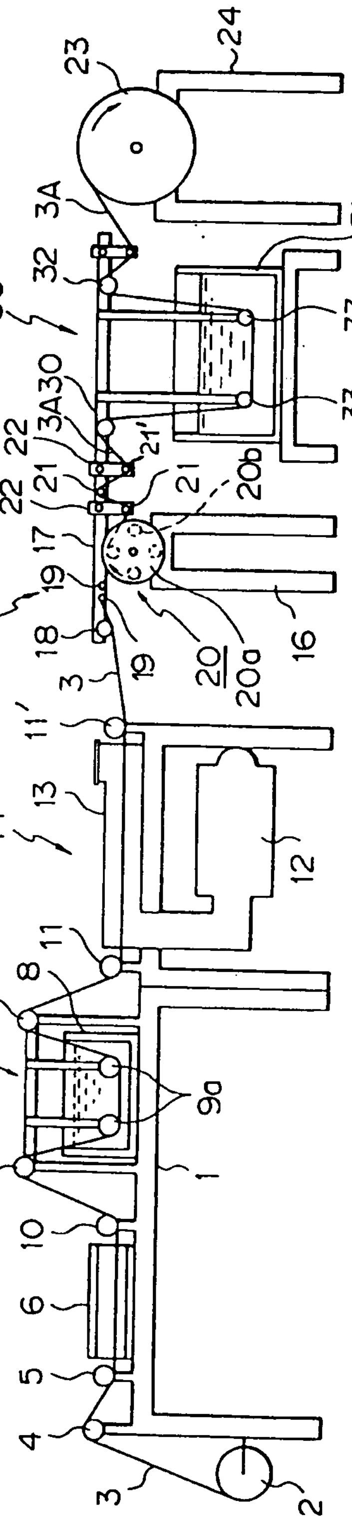

20
20a
20b
20'
II
21
3A
W
19
3

Fig. 1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21'
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3A
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23
24

Fig. 3

Fig. 2

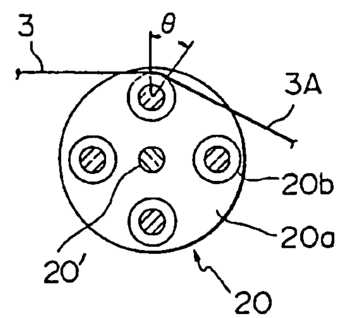

Fig. 4